Lead As A Stormwater Runoff Pollutant

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Lead Is a Constituent in Urban Area Street and Highway Stormwater Runoff that Is of Concern Because of Its Potential Impacts on Aquatic Life and Public Health

Review Current State of Knowledge on Public Health and Environmental Impacts of Urban Area Street and Highway Stormwater Runoff-Associated Lead and Lead Contaminated Soils Near Highways and Streets

Potential Public Health and Water Quality Significance of Lead

Lead Concentrations in Urban Area Street and Highway Stormwater Runoff Frequently Exceeds US EPA Water Quality Criteria

- Potential Toxicity to Aquatic Life
- Potential Bioaccumulation to Excessive Levels in Receiving Water Fish

Lead Concentrations in Soils Near Urban Area Streets and Highways Sufficient to Be Threat to Children's Health Who Consume the Soils During Play Activities

Former Use of Lead as an Additive in Gasoline Caused Many Soils near Highways and Streets to Accumulate Potentially Hazardous Levels of Lead

- Unleaded Gasoline Still Contains Potentially Significant Amounts of Lead

Lead Contaminated Soil Issues

California Department of Health Services (now Department of Toxic Substances Control - DTSC) Established 1,000 mg/kg Dry Weight Total Lead as a Concentration in a Waste that Would Cause the Waste to Be Classified as a Hazardous Waste

Highway Stormwater Runoff Conveyance Structures Accumulate Particulates which at Times Have Concentrations of Lead above DTSC Total Threshold Limit Concentration (TTLC) of 1,000 mg/kg.

NRDC vs. Caltrans District 7 Lawsuit Resulted in Decision that Is Causing Caltrans to Spend Millions of Dollars Managing Highway Stormwater Runoff Conveyance Structures' Accumulated Sediments as a Hazardous Waste Because of their Lead Content

Judge Ruled that Since DTSC Had Classified Sediments with Lead above 1,000 mg/kg as a Hazardous Waste, Sediments that Become Wastes Must Be Hazardous to Aquatic Life

- Did Not Understand the Basis for the Lead TTLC Value
- Not Related to Aquatic Life Impacts

Lead-Containing Soils as a Hazardous Waste

Some Soils in Urban Centers and Near Highways Contain Lead above 1,000 mg/kg, i.e., If These Soils Become a Waste, Must Be Managed as a Hazardous Waste

- Much More Expensive Management

DTSC Is in Process of Revising its Hazardous Waste Classification Approaches, Including TTLC Value for Lead

- Proposed Revision is 8,500 mg/kg

- Caltrans Stormwater Runoff Conveyance Structure Sediments as Well as Urban Area Street and Highway-Associated Soils Will No Longer Be Classified as Hazardous Waste Under DTSC Proposed Reclassification Approach

Lead as a Threat to Children's Health

Lead Is Recognized as One of the Most Significant Environmental Causes of Adverse Impacts to the Health of Children

Young Children Tend to Be Impacted by Lead through Neurological Damage at Much Lower Concentrations than Have Been Found to Impact Adults

Some Areas Regulate Soil Lead as Safe for Children's Play at 50 to 100 mg/kg

US EPA and State of California DTSC Recommended Soil Lead Values as Safe for Children Are Soils with Lead Less than 400 mg/kg

At Lead Concentrations between 400 to 2,000 mg/kg, Restrictions Should Be Implemented to Restrict Children's Exposure to Bare Soil

Above 2,000 mg/kg, Public Notice of Lead-Contaminated Soil Should Be Issued and Conditions Monitored

Above 5,000 mg/kg, Contaminated Soil Removal Action Should Be Implemented

US EPA Hazardous Waste Classification

Based on TCLP Tests, Leaching of Lead from Wastes Under Simulated Municipal Landfill Conditions

- If Leachable Lead in TCLP above 5 mg/L, Waste Is a Hazardous Waste
  - Based on 100 times Lead Drinking Water MCL
    - Arbitrarily Developed Value
    - Over-Protective in Some Areas; Under-Protective in Others
  - Only Applicable to Landfill Disposal Situations
    - Not Applicable to Classification of a Soil as a Hazardous Waste which Requires Management
- Revised Drinking Water MCL Now 15 μg/L
  - US EPA Still Using 5 mg/L Leachable Lead as Hazardous Waste Classification Level

  - DTSC Proposed to Decrease TCLP Leachable Lead for Hazardous Waste Classification to 1.5 mg/L, i.e. 100 times the Drinking Water MCL
    - Could Cause Soils that Become Wastes that Have Not in the Past Been Classified as Hazardous Waste to Become Classified as a Hazardous Waste in California

Aquatic Life Water Quality Impacts of Lead

It Has Been Known for Almost 30 Years that the Lead in Urban Area Street and Highway Stormwater Runoff Derived from Vehicular Traffic Is In Non-Toxic, Non-Available Form

Should Not Use Total Lead to Evaluate Conformance to US EPA Water Quality Criteria

Even Soluble Lead Likely Over-Estimates Water Quality Impacts of Lead to Aquatic Life

Cannot Estimate Toxic Lead Based on Chemical Analysis

- Must Use Toxicity Tests and TIEs to Evaluate Whether Lead in Urban Area Street and Highway Runoff Is Potentially Adverse to Receiving Water Aquatic Life - Requires Site-Specific Studies

Sediment Quality Impacts

Urban Area Street and Highway Stormwater Runoff-Associated Lead Accumulates in Receiving Water Sediments

Should Not Try to Use Chemically-Based Sediment Quality Guidelines, Such as Long and Morgan Guidelines, to Estimate Water Quality Significance of Lead in Sediments

- Co-Occurrence-Based Values Technically Invalid-Based on Total Concentrations of Constituent

Must Use Sediment Toxicity Tests and Sediment-Based TIEs to Determine Whether Lead in Sediments is in a Toxic, Available Form and Therefore Potentially Adverse to Water Quality

Bioaccumulation of Lead in Fish

In Some Instances Lead Bioaccumulates in Fish Tissue to Sufficient Extent to Represent a Hazard to Children Who Consume the Fish as Food

- Lead Fish Tissue Concentrations above 0.3 mg/kg for a One-Meal-per-Week Consumption Rate Potentially Hazardous to Children

Unknown Whether Urban Area Street and Highway Stormwater Runoff and Associated Soil Lead Is in a Form that Could Bioaccumulate in Aquatic Life Tissue to Hazardous Levels

- Doubtful that This Is a Problem

Independent Applicability of Chemical and Biological Criteria/Standards and Effluent Toxicity Testing

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In 1985 the U.S. Environmental Protection Agency (EPA) advocated a two-part approach for water pollution control involving chemical concentration-based effluent limits for those parameters for which water quality criteria had been developed and toxicity test-based effluent limitations. The chemical-specific component was designed to prevent exceedances of water quality criteria values in ambient waters receiving point and non-point source discharges or runoff; the water quality criteria were, in large part, developed to be chronic-exposure, safe concentrations for sensitive aquatic organisms. The toxicity test component was designed to indicate potential toxicity effects associated with an activity, to account for the possible presence of a toxic contaminant that did not have a water quality criterion, and to provide the opportunity for site-specific tuning of the chemical-specific criteria for synergism, antagonism, chemical availability, and exposure situations.

EPA has since expanded its recommended approaches to include a direct measure of biological characteristics (biological criteria) of surface waters. The biological criteria focus on the numbers, types and characteristics of organisms present downstream of a discharge or runoff compared with the numbers, types and characteristics expected based on the aquatic life habitat characteristics. A number of states have developed biological criteria and have been using them in water pollution control programs.

At a 1992 EPA workshop on water quality criteria and standards, EPA representatives revealed that the Agency would soon be releasing a position paper announcing the policy of "Independent Applicability." The June 1992 issue of EPA's "Newsletter Water Quality Criteria & Standards," however, stated that Independent Applicability is EPA's present position, and it is detailed in several documents. That inconsistency notwithstanding, the policy and/or practice of independent applicability and its ramifications for water pollution control in the country truly deserves a thorough examination.

The Problem with Independent Applicability

According to EPA in 1992, the three above-mentioned regulatory approaches for the regulation of toxics would be applicable to all waters, and the approach that was most "sensitive," (most limiting) for a particular waterbody would guide management. This led to many questions about how the policy would handle a situation in which:

- Biological studies of the receiving waters showed healthy and wholesome fish and other aquatic life populations, the same as those that would be expected based on habitat characteristics, and
- Short-term chronic toxicity testing of the waters in the region showed no aquatic life toxicity, but
- Numeric water quality criteria (or standards equivalent to them) were exceeded.

At that time, EPA stated that even under such circumstances, the discharger or source of runoff would have to implement control programs to eliminate the exceedances of the water quality criteria or standards, or change the standards. It was reported to be EPA's position under the policy of independent applicability to require that site-specific water quality criteria or standards be developed in order to justify not complying with EPA's water quality criteria, or more properly, state standards equivalent to those criteria.

It is appropriate to question the appropriateness of requiring dischargers and state regulatory agencies to develop site-specific water quality standards in response to that scenario (i.e., a situation in which it had been shown that there was no aquatic life toxicity in the receiving waters for the discharge/runoff and the populations of aquatic life in the region of expected impact were what would be expected based on habitat characteristics). There have been few attempts to develop site-specific water quality standards as outlined in EPA's Water Quality Criteria Handbook. As a consequence of the state of California Water Resources Control Board's adoption of EPA criteria as state water quality objectives (standards) in April 1991, a number of studies have been undertaken in California in an effort to develop site-specific objectives. More than $300,000 were spent in such effort in the San Francisco Bay area; more than $1.1 million were spent in efforts to develop site-specific criteria/standards for the Santa Ana River in southern California. However, as discussed below, the funds spent in trying to develop site-specific water quality objectives for copper in San

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Appropriate Use of Numeric Chemical Concentration-Based Water Quality Criteria

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INTRODUCTION

Increasing attention is being given to the cost-effectiveness of chemical contaminant control programs established to reduce toxicity to aquatic life in the watercolumn and sediment, and excessive bioaccumulation of contaminants in aquatic life. Evaluation and control of chemical contaminants has generally focused on either the effects of the contaminant(s) on aquatic organisms (biological effects-based approaches), or on concentrations of individual chemical contaminants with extrapolations to their impact on aquatic organisms (chemical concentration-based approaches).

Owing to their comparative simplicity and ostensible ease of application, chemical concentration-based state water quality standards based on or equivalent to US EPA numeric water quality criteria are being increasingly relied upon as independently applicable regulatory tools for the assessment, protection, and/or enhancement of designated beneficial uses of aquatic systems. However, the present-day use of such criteria and standards largely ignores the aqueous environmental chemistry and toxicology of contaminants, the worst-case or near-worst-case foundation of those criteria, and the fact that there is a large body of contaminants for which numeric concentration criteria do not exist. Each of these factors diminishes the reliability of the extrapolation of chemical concentrations to impacts on aquatic organisms/beneficial uses of water, and tends to make them more stringent than necessary to protect designated beneficial uses of waters. That notwithstanding, the US EPA has adopted the policy of Independent Applicability for chemical concentration criteria in which chemical-specific concentration values are applied independent of biological effects-based approaches for regulating "water quality". They are presumed to be independently reliable even when they indicate an "effect" that is not supported by biological effects-based approaches, such as toxicity testing and actual measurements of bioaccumulation evaluated on a site-specific basis.

Learned Discourses: Timely Scientific Opinions

Lee, G. F., and Jones-Lee, A., "Evaluation Monitoring as an Alternative to Conventional Stormwater Runoff Monitoring and BMP Development," *Learned Discourses: Timely Scientific Opinions, SETAC News* 17(2):20-21 March (1997).

Evaluation Monitoring as an Alternative to Conventional Stormwater Runoff Monitoring and BMP Development

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There is growing agreement (Urbanos and Tomo 1994; Herricks 1995; Lee and Jones-Lee 1994, 1996a) that conventional stormwater runoff monitoring for a suite of chemicals at the storm sewer outfall or edge-of-the-pavement is of limited value in defining real water quality problems caused by chemicals in stormwater runoff. There is also increasing recognition that conventional best management practices (BMPs) such as detention basins, filters, etc. are not real BMPs for controlling water quality use impairments in waterbodies receiving urban area street and highway stormwater runoff. An alternative monitoring and BMP development approach is "Evaluation Monitoring."

Evaluation Monitoring assesses the impact of stormwater runoff-associated constituents from a water quality use impairment perspective. Conventional monitoring develops chemical data via edge-of-the-pavement sampling and tries, usually with little or no success, to extrapolate to receiving water impacts. Evaluation Monitoring is a watershed-based water quality evaluation and management program in which the stakeholders concerned about water quality in a particular waterbody work together to define the water quality use impairments that are occurring in a waterbody and the cause of the use impairments. They then work to develop control programs to limit the amounts of the constituents responsible for the use impairments entering the waterbody of concern.

For example, many heavy metals and organics are of concern in urban area street and highway stormwater runoff because of their potential toxicity to aquatic life. Conventional stormwater runoff monitoring generates data that indicate that potentially significant elevated concentrations of heavy metals are present in urban area street and highway runoff. However, the chemical data developed from such monitoring cannot be used to determine whether the concentrations found in the runoff are in toxic, available forms and whether the toxicity associated with these constituents will be present at toxic levels in the receiving waters for a sufficient time to be significantly toxic to receiving water aquatic life.

Evaluation Monitoring measures the amount of toxicity in the stormwater runoff as it enters the waterbody of concern using U.S. EPA standard ambient water toxicity tests. Where potentially significant toxicity is found in the runoff waters entering a waterbody, site-specific studies are conducted to determine whether the toxicity in a stormwater runoff event is of sufficient magnitude and duration to be potentially adverse to the receiving water aquatic life. If such conditions are found, then through toxicity investigation evaluations (TIEs) the constituents responsible for the toxicity are determined and through forensic studies the sources of these constituents within the watershed are evaluated.

In the Evaluation Monitoring approach, rather than assuming that conventional BMPs, such as detention basins and filters, are effective in controlling potential water quality use impairments in the receiving waters for stormwater runoff, site-specific BMPs are developed to control real water quality use impairments to the maximum extent practicable (MEP). Typically, these BMPs focus on source control that manages the input of the chemical species of concern using BMPs to the MEP. These BMPs, in most cases, will be significantly different from the conventional stormwater runoff BMPs used today since they will focus on dissolved, toxic/available forms rather than particulate, non-toxic forms.

In order to manage water quality problems due to potential bioaccumulatable chemicals such as the chlorinated hydrocarbons and mercury, the focus of Evaluation Monitoring is on determining whether excessive concentrations of these chemicals are found in receiving water fish. Fish tissue analysis is used to determine whether there is a water quality problem due to excessive bioaccumulation. In contrast, conventional stormwater monitoring tries to extrapolate from the constituents in stormwater runoff to tissue concentrations. This approach is normally of limited reliability since there are a variety of factors that influence whether a chemical constituent in runoff waters bioaccumulates to excessive levels in receiving water aquatic organisms. For example, for mercury, the conventional monitoring approach extrapolates from stormwater runoff mercury concentrations to receiving water concentrations of methylmercury which accumulate in fish tissue to excessive levels. Such approaches have limited reliability because of the complex aqueous environmental chemistry of mercury.

Evaluation Monitoring is a cost-effective, technically valid approach for evaluating whether regulated heavy metals and organics as well as unregulated constituents in urban area street and highway stormwater runoff are adverse to the designated beneficial uses of the waters receiving the runoff. The various potential water quality use impairments of concern such as aquatic life toxicity, domestic water supply, excessive hazardous chemical bioaccumulation, excessive fertilization, sanitary quality, petroleum hydrocarbon - oil and grease, litter, and excessive sediment accumulation or impacts are evaluated in the Evaluation Monitoring program in terms of their significance in impairing the beneficial uses of the waterbody (Lee and Jones-Lee 1996b,c).

Where significant receiving water beneficial use impairment occurs, the waterbody stakeholders work together to define through forensic analysis the sources of constituents responsible for impairment and then develop programs to control the impairment to the MEP. A three-year demonstration project is currently underway in Orange County, California for stormwater runoff water quality management in Upper Newport Bay. This program is being conducted in cooperation with the Orange County Environmental Management Agency and the Santa Ana Regional Water Quality Control Board as well as other stakeholders within the Upper Newport Bay watershed.

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Assessing Water Quality Impacts of Stormwater Runoff

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Abstract

Current "water quality" monitoring of non-point source runoff typically involves periodically measuring a laundry list of chemicals in the runoff waters. This approach, while satisfying regulatory requirements, provides little to no useful information on the impact of the chemicals in the runoff on the real water quality - designated beneficial uses of the receiving waters for the runoff. There is need to focus water quality monitoring on investigating the receiving waters in order to assess whether the chemicals in the runoff are adversely affecting beneficial uses. This paper presents an evaluation monitoring approach for monitoring receiving waters that determines whether the runoff is a significant cause of water quality - use impairments. For each type of use impairment, such as aquatic life toxicity, excessive bioaccumulation of hazardous chemicals, excessive fertilization, etc., highly focused site-specific studies are conducted to determine the use impairment that is likely occurring due to a stormwater runoff event(s) and the specific cause of this impairment.

Introduction

There is growing recognition that domestic and industrial wastewater and stormwater runoff "water quality" monitoring involving the measurement of a suite of chemical "pollutant" parameters in discharge/runoff waters is largely a waste of money. For stormwater runoff, such programs generate more data of the type that have been available since the 1960's on the chemical characteristics of urban area, highway and street runoff. It has been known since that time that runoff from these areas contains a variety of regulated chemical constituents and

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Soil-Lead Remediation

Cover Lead-Contaminated Soils with Clean Soil

2 ft Inadequate - 5 ft More Appropriate

Must Consider Ability to Forever Implement Reliable Use-Restrictions That Do Not Result in Lead-Containing Soils' Being Brought to the Surface by
- Excavation
- Translocation by Plants

Soil-Lead Fixation

May Be Able to "Fix" - Immobilize - Soil-Lead by Addition of Reagents

Less Available for Transport and Uptake

Phosphate Addition May Be Effective

Conclusions

- The California TTCL Hazardous Waste Lead Concentration of 1,000 mg/kg Over-Estimates the Hazardous Levels of Lead to Adults
- Recent Re-Evaluation of the Public Health Significance of Lead in Soils and Sediments Increased the Concentrations of Lead Thought to Be Harmful to Children's Health through Play Activities
- Particulate Lead Accumulated in Highway Urban Area and Street Stormwater Conveyance Structures Not Likely a Threat to Public Health Unless Concentrations Are above 2,000 mg/kg and Children Frequently Play on Bare Soils Containing Those Concentrations, for Extended Periods
- Lead in Highway Urban Area and Street Stormwater Runoff That Exceeds US EPA Water Quality Criterion Is Not Likely Adverse to Aquatic Life in Receiving Water through Either Water Column or Sediment Toxicity

Lead in Urban Area Streets and Highway Stormwater Runoff and Associated Soils Is, in General, Being Over-Regulated Today - Need Site-Specific Evaluation

Water Quality and Solid & Hazardous Waste Landfills Evaluation and Management

Dr. G. Fred Lee and Dr. Anne Jones-Lee have developed a Web Site:

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in which they list some of their recent professional papers and reports devoted to public health and environmental quality aspects of domestic water supply water quality, water and wastewater treatment, water pollution control, and the evaluation and management of impacts of solid and hazardous waste. The major topic areas of this Web Site are:

- Landfills - Solid and Hazardous Waste Impact Evaluation and Development
- Water Quality Evaluation & Management for Wastewater Discharges and Stormwater Runoff
- Hazardous Chemical Impact - Superfund - Evaluation and Remediation/Management
  Davis South Campus Superfund Oversight Committee Activities
- Contaminated Sediments - Aquafund - Water Quality Impact Evaluation and Management
- Domestic Water Supply Water Quality- Watershed Management
- Reuse of Reclaimed Wastewaters for Groundwater Recharge and Shrubbery Irrigation
- Excessive Fertilization/Eutrophication of Lakes, Reservoirs, Estuaries, and Marine Waters
- Watershed Based Water Quality Management
  Sacramento River and Delta Water Quality Issues
  Upper Newport Bay, California Water Quality Issues
- Information on G. Fred Lee & Associates

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RECENT PUBLICATIONS OF
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Listed below are several of the recent publications and reports prepared by Drs. G. Fred Lee and Anne Jones-Lee pertinent to regulating lead in stormwater runoff and lead contaminated soils. A copy of these publications may be obtained upon request.

Lee, G.F. and Jones-Lee, A., "Lead as a Stormwater Runoff Pollutant," Report of G. Fred Lee & Associates, El Macero, CA, June (1997).

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